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III. *A Letter of Dr. Wallis to Dr. Sloane, concerning the Generation of Hail, and of Thunder and Lightning, and the Effects thereof.*

Oxford, July 26. 1697.

S I R,

I Thank you for the Transactions of *June*, which you sent me; wherein I am well pleased with Mr *Hally's* Remarks on the Torricellian Experiment at the Top of *Snowdon-Hill* in *Wales*, at the Height of 1240 Yards Perpendicular. Where the Height of that Quicksilver in the Baroscope was 3 Inches and  $\frac{1}{2}$ . less than below at the Sea-side: Which is an Observation of good use: and would have been more so, had he had the Leisure to make like Observations at several other Perpendicular Heights in the Ascent. For from such comparative Observations, we are to make an Estimate, at what Proportion the Height of the Quicksilver doth decrease in reference to the Height of the Place. I mean whether in the same Proportion, or the Duplicate, Sub-duplicate, or how otherwise Complicate thereof. From whence we may make a Judgment of the Height of the Atmosphere, if at least it have a determinate Height. I did once attempt (a great while since) a Computation of it; but wanted a sufficient Number of *Data* to proceed upon.

But that which is most surprising in those Transactions is, the prodigious *Hails* there mentioned;  
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which happened at many Places, on different Days, and all within the compass of less than Six Weeks. I have been told of the like in other Places about the same Time, in *Lincolnshire*, *Hampshire*, and elsewhere; whether or no on the same Days which you mention, I cannot tell; nor can I give a particular Account of them. But it would be kind in those who can, to give you like Accounts thereof with those you have Published, for a like Publick Information.

I find it is thought very strange, what should cause so sudden a Congelation of Hail-stones to so great a Bigness before they fell. And it is indeed very strange. But it is not necessary that the whole Bigness be attained before they begin to fall, but the freezing may continue during the Fall, to increase the Bulk. For I remember that (many Years since) I observed here at *Oxford*, a strange Shower of Hail, wherein (besides the formed Stones that fell on the Ground) there did hang on the Trees a great deal in the Form of Icicles (a Foot or more in length) so many and heavy, as to break off some Boughs with their Weight; and I was then told, that in some Places great Branches of Trees were so broken off; which must needs be from the continuing to freeze during the fall.

And truly the Generation of Hail in general, is a thing which deserves to be farther inquired into, than (I think) hath yet been done. I find Mr. *Hally* (in his Narration) ascribing it to a *Vapour disposing the Aqueous Parts so to congeal*. And not unlikely.

If I may interpose my Opinion; you may take it thus :

Thunder and Lightning are so very like the Effects of fired Gun-powder, that we may reasonably judge them to proceed from like Causes. The violent Explosion of Gun-Powder, attended with the Noise and Flash, is so like that of Thunder and Lightning, as if they differed only as natural and Artificial; as if Thunder and Lightning were a kind of Natural Gun-powder, and this a kind of Artificial Thunder and Lightning.

Now the principal Ingredients in Gun-powder are, Nitre and Sulphur (the Admission of Char-cole being chiefly to keep the Parts separate for the better kindling of it). So that if we suppose in the Air, a convenient Mixture of Nitrous and Sulphurous Vapours, and those by Accident to take Fire; such Explosion may well follow, with such Noise and Light, as in the firing of Gun-powder. And being once kindled, it will run on from Place to Place as the Vapour leads it, as in a Train of Gun-powder, with like Effects.

This Explosion, if high in the Air, and far from us, will do no Mischief, or not considerable; like a parcel of Gun-powder fired in the open Air, where is nothing near to be hurt by it: But if near, to us (or amongst us) it may kill Men or Cattle, tear Trees, fire Gun-powder, break Houses, or the like; as Gun-powder would do in like Circumstances.

Now this nearness or farness may be estimated by the Distance of Time between seeing the Flash of Lightning, and hearing the Noise of the Thunder. For though in their Generation, they be simultaneous; yet (Light moving faster than Sound) they come to us successively. I have observed that, commonly, the Noise is about Seven or Eight Seconds after the Flash (that is, about half a quarter of a Minute); but sometimes much sooner, in a Second or Two, or less than so, and almost immediately upon the Flash. And at such time, the Explosion must needs be very near us, or even amongst us. And, in such Cases, I have (more than once) presaged the Expectation of Mischief, and it hath proved accordingly, in the Destruction of Men or Cattel, and the like. (As once at *Oxford*; when, within half an Hour after such Presage, I heard of one killed at *Medley*, hard by, and others endangered; and another time at *Towcester*, when within a few Hours after, we heard of Five Persons killed at *Everton*, about Four or Five Miles from us, and others wounded; beside other Hurt done.)

Now, that there is in Lightning a Sulphurous Vapour, is manifest from the Sulphurous Smell which attends it, especially when Hurt is done; and even where no Hurt is done, from the Lightning it self, more or less discernable. And a foultry Heat in the Air, is commonly a Fore-runner of Lightning soon after.

And that there is also a Nitrous Vapour with it, we may reasonably judge, because we do not know  
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of any Body so liable to a suddain and violent Explosion.

Now these Materials being admitted, it remains to be considered, how they may be kindled in order to such Explosion. As to which, I have been told from Chymists (though I have not seen it tryed) That a Mixture of Sulphur, Filings of Steel, with the Admission of a little Water, will not only cause a great Effervescence, but will of it self break forth into an actual Fire.

So that there wants only some Chalybeat or Vitriolick Vapour (or somewhat equivalent) to produce the whole Effect (there being no want of Aqueous Matter in the Clouds.)

And there is no doubt, but that amongst the various *Effluvia* from the Earth, there may be copious Supplies of Matter for such Mixtions.

And 'tis known, that Hay, if laid up too Green, will not only heat, but take Fire of it self.

And while we are discoursing of this, it may suggest somewhat as to the Generation of Hail, which is very oft an attendant of Thunder and Lightning. 'Tis well known, in our artificial Congelations, that a Mixture of Snow and Nitre (or even common Salt) will cause a present and very sudden Congelation of Water. And the same in Clouds may cause that of Hail-stones. And the rather, because (not only in those prodigiously great, but in common Hail-stones) there seems somewhat like Snow rather than Ice, in the midst of them.

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And, as to those in Particular (of which we are now speaking) so very large (as to weigh Half a Pound, or Three Quarters of a Pound) supposing them to fall from so great a Height, as 'tis manifest they did by the Violence of their Fall: 'Tis very possible, that, though their first Concretion, upon their suddain Congelation, might be but moderately great, as in other Hail; yet, in their long Descent, if the *Medium* through which they fall were alike inclined to Congelation, they might receive a great Accession to their Bulk, and divers of them incorporate into one. Like as in those Icicles before mentioned.

These have been my Thoughts, occasioned by the Consideration of the surprizing Greatness of these Hail-stones, with the great Thunder and Lightning which did attend these Storms.

T O U R S, &c.

IV. *Extract*